

## **STUDY OF THE ABSORPTION OF DIODE PUMPED SOLID STATE LASER ON Ti:SAPPHIRE CRYSTAL**

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### **ABSTRACT**

Exciting laser material is a challenging task. Only certain source is appropriate to pump the electron to an excited state. This depends on how much the pumped source will absorb and cause the fluorescence. Hence, this research was carried out to estimate the percentage of energy absorbed in the laser material. In this case, Ti:sapphire crystal was employed as an active medium. High power diode laser was used as a pumping source. A powermeter was utilized to measure the output of the beam. The absorbance power was estimated to be 1.29 W from the result of transmission and reflection measurement.

**Keywords:** DPSS, absorbance power, transmission, reflection

### **INTRODUCTION**

Titanium doped Sapphire ( $\text{Ti}^{3+}:\text{Al}_2\text{O}_3$ ) or Ti:Sapphire was developed late in laser evolution. However, since the discovery of laser action in Ti:sapphire in 1982, it became one of the most widely used solid-state laser material [1]. It combines the excellent thermal, physical and optical properties of Sapphire with the broadest tunable range of any known material [2]. It can be lased over the entire band from 660 to 1100 nm. Frequency doubling provides tunability over the blue-green region of the visible spectrum.

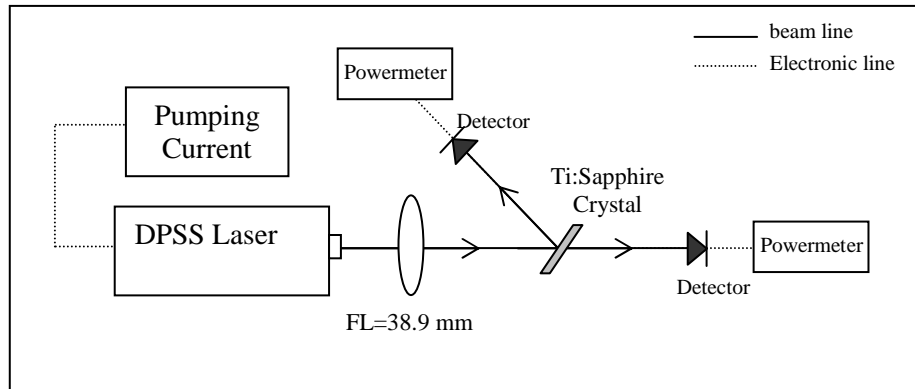
Ti:Sapphire crystals are active media for highly efficient tunable solid-state lasers. They demonstrate good operation in the pulsed-periodic, quasi-CW and CW modes of operation. Ti:Sapphire is a 4-level, vibronic laser with fluorescence lifetime of 3.6  $\mu\text{s}$ . The absorption spectrum of Ti:sapphire peaks at around 500 nm. Ti:sapphire can be pumped by variety of sources operating in the green-argon ion, copper vapour, frequency-doubled Nd:YAG, and dye lasers are routinely used. Crystals have also been flashlight pumped by lamps designed to allow short fluorescence lifetime. These factors and broad tunability make it an excellent replacement for several common dye lasing materials.

Laser-diode-pumped solid-state lasers have a wide variety of applications due to their high efficiency, compactness and good frequency stability. Since the early 1980s, with the development of the reliable high power LDs, LD pumped solid state lasers have been attracting a great deal of attention [3]. The diode pumped solid state (DPSS) lasers, compared to the traditional flashlamp pumped ones, have the characteristics of being more efficient, compact, versatile, stable and reliable, which allowed them to be used in a wide range of applications with improved performance [4].

For the commercial Ti:sapphire laser, frequency doubled Nd:YAG or Nd:YLF lasers were used as a pumping source to pump Ti:sapphire crystal [5]. The most important application of Ti:sapphire lasers is the generation and amplification of femtosecond mode-locked pulse [6]. Thus, in this experiment Diode Pumped Solid State Laser was used to study the optical properties of Ti:sapphire crystal prior to its application.

## METHODOLOGY

A Diode Pumped Solid State (DPSS) laser was used as a source of light. The wavelength of the laser is 532 nm and operated in continuous mode. A lens with focal length of 38.9 mm was used to focus the DPSS beam on the crystal. The optical properties of the beam after illuminated on the Ti:sapphire crystal were measured which include the incident, reflection and the transmission. The 3APSH Melles Griott powermeter was utilized to measure the power of the beam. The power of the laser was verified via the pumping currents. The whole arrangement of experimental setup is shown in Figure 1.



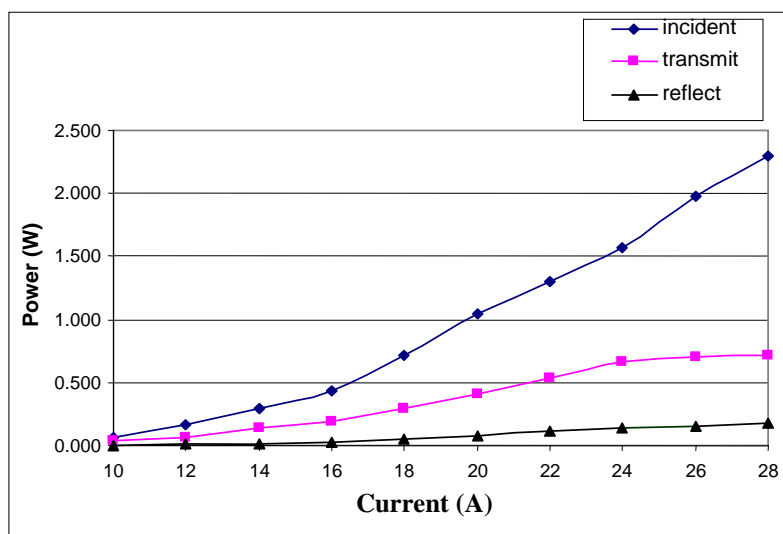
**Figure 1:** Schematic diagram of the whole experiment

Ti:sapphire crystal has dimension of  $5 \times 5 \times 3 \text{ mm}^3$ . The crystal is cut at Brewster angle of  $60.3^\circ$  with refractive index of 1.75. The amount of Titanium doped into the sapphire was 0.25% in weight. Ti:sapphire also have many other desirable characteristics such as very high damage threshold ( $\approx 8\text{-}10 \text{ J/cm}^2$ ), high thermal conductivity ( $46 \text{ W/mK}$  at  $300 \text{ K}$ ), and suitable peak gain cross section  $\approx 2.7 \times 10^{-19} \text{ cm}^2$  [7].

## RESULT AND DISCUSSION

Initially, the output of DPSS laser was measured directly upon the pumping current. This particular measurement is also considered as the total incident power since the output beam spot considerably larger than the area of target material of Ti:sapphire crystal, the beams have to be focused using biconvex lens with a focal length of 38.9 mm. In fact this is a similar situation in most laser Ti:sapphire laser resonator. Although the crystal has been cut at Brewster angle, in reality there is still some amount of beam being reflected. Therefore it is important to measure the reflection portion prior for lasing alignment setup. For estimation of the absorption beam in the crystal, the transmission beam needs to be measured.

The data collected from this experiment are used to plot graph such as shown in Figure 2. The power for different portion of beam is plotted against the pumping current of DPSS laser. This source commonly used as a pumping energy for Ti:sapphire laser. Generally, most curves shown similar trend which gradually increased with the pumping current. The incident power obviously indicates the highest power. The linear portion of the graph having a slope efficiency of  $0.255 \text{ W/A}$ . The maximum power of DPSS laser was obtained as  $2.3 \text{ W}$ . This is the power required for pumping process.



**Figure 2:** Power incident, transmitted and reflected as a function of Power.

The second curve of the graph in Figure 2 represents the transmission beam. The maximum power produced for such transmission was 0.72 W corresponding to the pumping current of 28 A. Hence the percentage of transmission beam out of the system was 31.30%.

The lowest curve of Figure 2 represents the reflection portion of the DPSS beam. The maximum power of the reflection beam was obtained as 0.175 W which corresponding to the same maximum pumping current. The percentage of reflected beam was 7.61%.

Taking into account of other phenomena of light scattering and the error of the measurement as 5%, the total absorption of green light of DPSS laser in the Ti:sapphire crystal was estimated as 56.08%. The equivalent power of absorption in this case was 1.29W.

## CONCLUSION

Optical properties of the Ti:sapphire upon a visible light of DPSS laser were successfully studied. The percentage of reflected, transmitted and absorption beam after considering the percentage of error are 31%, 7% and 56% respectively. The maximum power of absorption was equivalent as 1.29 W.

## ACKNOWLEDGMENT

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